Financial Evaluation of the Post-Acute Care Plan for Stroke in Taiwan's Healthcare Policy

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ABSTRACT

Stroke hits approximately 800,000 people in the U.S. and 40,000 people in Taiwan annually. By 2012, stroke patients in the U.S. and Taiwan were reimbursed through a fee-for-service system. In 2015, Taiwan's National Healthcare Insurance (NHI) implemented a prospective payment system for stroke patients. Under this system, a post-acute care (PAC) plan provides a stroke patient with intense rehabilitation services for a certain duration, after which the patient is forced to transfer to a long-term care institute or home care. From a financial point of view, this study develops a Markov chain model to formulate the distinct treatment pathways of those patients who have joined the PAC plan and those who have not joined. A formula is developed from the model to compute the average cost of treatment. An empirical analysis on the model was conducted using data collected from a regional hospital in Taiwan. The findings suggest that, without considering clinical effectiveness, NHI's payment for a PAC patient is smaller than that for a non-PAC patient.

Keywords: Financial evaluation; Markov chain; Health insurance; Post-acute care.

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1. INTRODUCTION

Stroke hits approximately 800,000 people in the U.S. (Buntin, *et al.*, 2010) and 40,000 people in Taiwan (Lai, 2017) annually. In Taiwan, the average duration of hospitalization for a stroke patient is approximately 17.8 days. The total costs of hospitalization for all stroke patients were around 30.9 billion NT dollars in 2020 (i.e., approximately 1 billion USD) (National Healthcare Institute, 2020). Strokes can be classified into two major types, namely, ischemic stroke and hemorrhagic stroke (Kidwell and Warach, 2003). Ischemic stroke is caused by an interruption of blood supply to the brain, while hemorrhagic stroke is caused by the rupture of a blood vessel or an abnormal vascular structure. In 2013, approximately 6.9 million people and 3.4 million people worldwide suffered from ischemic stroke and hemorrhagic stroke, respectively (GBD, 2016).

Stroke causes various degrees of functional disability to the patients. After the acute treatment phase, most stroke patients need to undergo post-acute care (PAC) that improves their functional progress, reduces their disability, and enables them to return to their homes and the community. After-stroke rehabilitative services are therefore a

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major mechanism for stroke patients to regain independence in their daily life. In the U.S., Medicare's payments on PAC increased by 9% and amounted to 15% of the total Medicare payments annually since 2000 (Centers for Medicare & Medicaid Services, 2020). By 2012 in Taiwan, reimbursements to stroke patients were under a fee-for-service system with a constraint (also called a protocol) requiring that a stroke patient cannot stay at the same hospital continuously for more than one month. This protocol implicitly requires stroke patients to eagerly undergo rehabilitation and to transfer to long-term care institutes and home care. However, this protocol did not work well as expected because the fees for long-term care are mostly borne by the patients rather than by the government. As a consequence, after one month of free hospitalization at a particular hospital, a stroke patient tends to transfer to another hospital where a bed is available for an extra month of free hospitalization.

Given the increasing healthcare costs, budgeting healthcare resources is an important task for the government to provide sustainable public healthcare services and insurance (Anggraini and Ridho, 2016; Song *et al.*, 2012). In 2015, Taiwan's National Healthcare Insurance (NHI) implemented a prospective payment system for stroke patients. Under the new system, after a stroke patient has completed the acute treatment phase, he/she can choose to join a PAC plan (and thus becomes a "PAC patient") that provides him/her with intense rehabilitation for a maximum of 12 weeks. After the intense rehabilitation period, the patient is required to transfer to a long-term care institute or home care. In other words, NHI initially provides a PAC patient with intensive treatment and then will no longer pay for the patient's hospitalization after 12 weeks of intense rehabilitation. Unlike the U.S. Medicare, Taiwan's NHI does not enforce every stroke patient to join the PAC plan. One reason is that the clinical effects of the PAC plan are not yet empirically proven; another reason is that the cost-saving effect of the PAC plan is not yet confirmed. This study conducts a quantitative financial evaluation of the PAC plan in Taiwan to investigate whether this plan can achieve the cost-saving purpose.

2. DATA and METHODOLOGY

To encourage hospitals in persuading their stroke patients to join the PAC plan, Taiwan's NHI provides every PAC patient with a higher payment for covering more flexible and intensive rehabilitative treatments. For instance, the NHI payment for a non-PAC patient is NT$ 1,533 (approximately USD 50) per day, while the payment for a PAC patient can be as high as NT$ 3,587 (approximately USD 119) per day. In addition, NHI gives a bonus to the hospital if a PAC patient achieves significant improvement in functional recovery and independence. The total amount of bonus paid to a hospital is over the range of NT$ 60,000 (approximately USD 2,000) to NT$ 210,000 (approximately USD 70,000) a year, depending on the hospital's rehabilitation performance. As such, hospitals are motivated to allocate more of their resources to PAC patients.

2.1 Computational Model

The PAC plan is executed on a weekly basis with its continuity in the following week depending on the rehabilitative treatment outcome in the preceding week. The rehabilitation of a PAC patient involves a state transition from one week (the current state) to the next week (the next state) until the end of the plan. For a non-PAC patient, he/she initially receives one-month hospitalization and can apply for re-admission at anther hospital where a bed is available. Various models were widely used to evaluate the performance and feasibility of a plan in many disciplines (e.g., Nobuyuki Kobayashi,

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Aki Nakamoto, *et al*. 2018). In the context of this study, the treatment strategies for PAC and non-PAC patients can be modeled using the Markov chain (Geyer, 1991), which is a graphical approach denoting transitions between different states. A Markov chain model consists of nodes and related edges, where a node (or, a state) denotes a problem situation, and an edge is how the transition between any two states is directed. As such, the current state can transit to another state if an event occurs. The Markov chain is a powerful tool for expressing a problem space with finite situations (or, states) as well as the possible transitions between different states. In general, the transition from one state to another follows some probabilistic rules.

This study adopts the Markov chain to capture the intensive rehabilitative treatment evolution along the distinct treatment pathways of PAC and non-PAC patients. From a financial evaluation perspective, the *n*-th state in the Markov chain represents the *n*-th period of rehabilitative treatment of a patient. The rehabilitative treatment duration for a PAC patient is counted in week, while that for a non-PAC patient is counted in month. Figure 1 shows the treatment Markov chain for a PAC patient, where nodes w_0 to w_{12} represent states (or weeks) of rehabilitative treatment for the PAC patient, node w_0 denotes the initial state, and node *E* denotes the termination of the PAC plan. Once the patient joins the PAC treatment, he/she will enter the Markov chain from node w_0 to node w_1, meaning that the patient starts to receive intensive rehabilitative treatment in the first week. As the severity of disability varies from patients to patients, a PAC patient may continue to receive treatment for weeks until his/her health condition is improved. Thus, a transition exists from node w_k to the next state w_{k+1} or state *E*, where $1 \leq k < 12$. Note that the next state of node w_{12} must be node *E* because the PAC protocol provides a PAC patient with intensive rehabilitative treatment for a maximum of 12 weeks.

The edge between two states in Figure 1 denotes the transition of a PAC patient's treatment from the current state (week) to the next state (week). The next possible state of the patient varies as the rehabilitative treatment progresses. For simplicity, this study uses a probability to denote the possibility of the transition from the current state to the next state. Specifically, $P_{m,n}^{pac}$ is attached to an edge to denote the probability that a PAC patient will transit to the next state *n* if he/she is in the current state *m*, where $m < n$ with *m* being an element in $\{w_0, w_1, w_2, \cdots, w_{12}\}$ and *n* being an element in $\{E, w_1, w_2, \cdots, w_{12}\}$. Note that $P_{m,m+1}^{pac} + P_{m,E}^{pac} = 1$ because there are only two possible states for the next transition. In addition, two boundary probabilities exist: $P_{0,1}^{pac}$ and $P_{12,E}^{pac}$, where $P_{0,1}^{pac}$ is the probability that the patient will join the PAC plan and $P_{12,E}^{pac}$ =1 because the intensive rehabilitative treatment received by the PAC patient must terminate after the 12th week.

Given that NHI provides each PAC patient with rehabilitative treatment for a maximum of 12 weeks, the 12 alternative cases for a PAC patient are listed as follows:
Case 1: complete the intensive rehabilitative treatment in the first week.
Case 2: complete the intensive rehabilitative treatment in the second week.
Case 3: complete the intensive rehabilitative treatment in the third week.
⋮
Case 12: complete the intensive rehabilitative treatment in the twelfth week.

Let C_k^{pac} be the treatment cost of a PAC patient receiving treatment in the *k*th week, where $1 \leq k \leq 12$. The average treatment cost of the PAC plan can be computed by the following equation:

$$C_k^{pac} = C_1^{pac} + P_{1,2}^{pac} \times C_2^{pac} + P_{1,2}^{pac} \times P_{2,3}^{pac} \times C_3^{pac} + \cdots$$

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$$= C_1^{pac} + \sum_{m=1}^{11}\left(\left(\prod_{k=1}^{m} P_{k,k+1}^{pac}\right) \times C_{k+1}^{pac}\right) \quad (1)$$

The average treatment cost of the PAC plan can be calculated using Equation (1) if the probability of each transition and the treatment cost in each state are known.

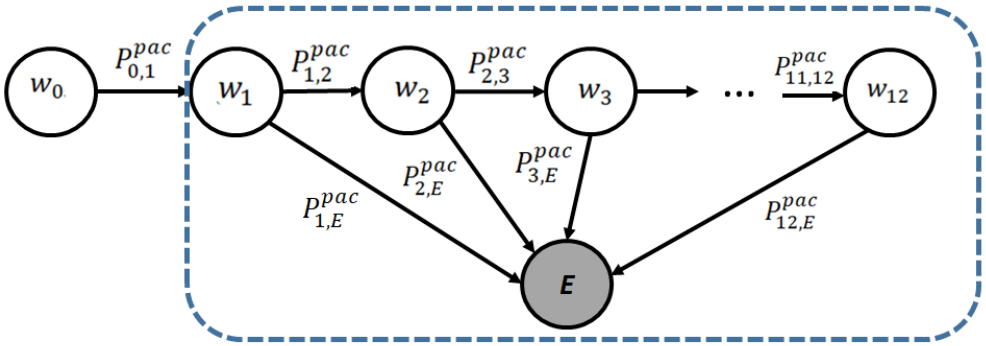

Figure 1. The treatment Markov chain for a PAC patient

A patient may not join the PAC plan for various reasons such as business insurance coverage. Given that healthcare resources are limited, non-PAC patients cannot stay at hospitals for too long. NHI usually transfer non-PAC patients to long-term care institutes and the community after one-month hospitalization. Since the costs of long-term care institutes and living support in the community are not covered by NHI, a non-PAC patient will try to be admitted to another hospital for an extra month of free hospitalization after staying in the community or a long-term care institute for a short period of time. The PAC plan does not allow a patient to join after an acute period of treatment for stroke, so a non-PAC patient is unable to enter the PAC Markov chain in Figure 1. Instead, the treatment pathway of a non-PAC patient can be delineated in Figure 2 showing a non-PAC patient's (multiple) transitions between hospital and the community, where node m_0 denotes the initial state in which the patient has completed the acute treatment, and node m_k represents the *k*-th state (or *k*-th month) of hospitalization. Suppose a patient has completed the *k*-th month of hospitalization (i.e., in state m_k), he/she will be requested to return to the community or a long-term care institute (i.e., in state c_k). The patient will return to hospitalization for one month if another hospital has a bed available, which is denoted as a transition from state c_k to state m_{k+1} in Figure 2. If the patient's health status is good enough, he/she will not be admitted to a hospital, which is denoted as a transition from state c_k to state *E* in Figure 2. Given that NHI does not allow a stroke patient to extend his/her hospitalization, state *F* in Figure 2 denotes the final state of hospitalization for the patient. The value of *F* is usually smaller than 10.

Similar to that in Figure 1, the edge between any two states in Figure 2 denotes the patient's transition from one state to another. The next state of a patient depends on the availability of a hospital bed and the patient's health status. This paper uses probability to denote the possibility of the next state transited from current state. $P_{s,t}^{npac}$ is attached to each edge to denote the probability that a non-PAC patient is transited to next state *t* if he/she has completed the *s*th-month hospitalization, where $s < t$ with *s* being an element in $\{m_0, m_1, m_3, \cdots, m_F, c_1, c_2, c_3, \cdots, c_F\}$ and *t* being an element in $\{E, m_1, m_2, \cdots, m_F, c_1, c_2, c_3, \cdots, c_F\}$.

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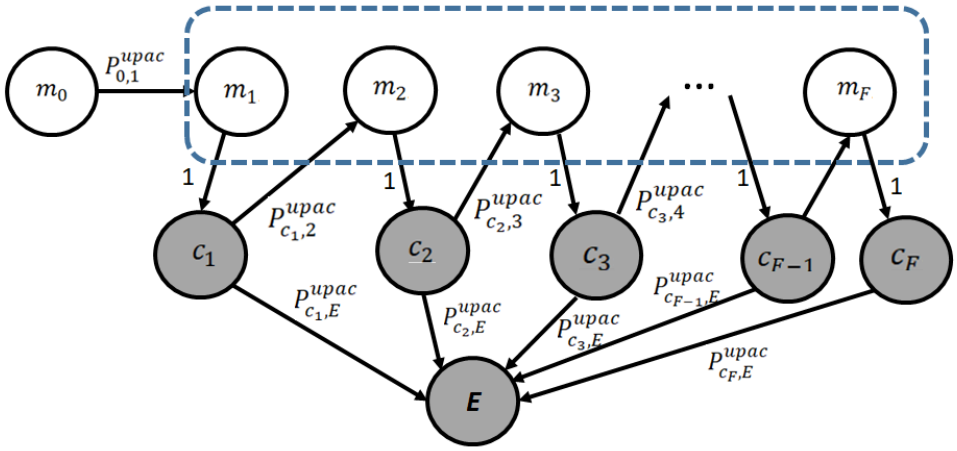

Figure 2. The treatment Markov chain for a non-PAC patient

$P_{c_s,s+1}^{npac} + P_{c_s,E}^{npac} = 1$ because, for a non-PAC patient currently in state c_s (i.e., in the community or a long-term care institute), there are only two possibilities for the next transition, that are state m_{s+1} (i.e., transiting to the next hospital) and state *E* (i.e., non-re-admission). In addition, the two boundary probabilities are $P_{0,1}^{npac}$ and P_{F,c_F}^{npac}, where $P_{0,1}^{npac}$ represents the probability that the non-PAC patient will not join the PAC plan, and $P_{F,c_F}^{npac}=1$ because the non-PAC patient cannot receive further hospitalization after the *F*-th month of hospitalization. The average treatment cost paid by NHI for a non-PAC patient is represented by the sum of the items inside the dotted rectangle in Figure 2. The following are the *F* alternative cases for a non-PAC patient:

Case 1: Receive the first month of hospitalization and then return to the community. The state-transition sequence is (m_1, c_1, E).

Case 2: Receive the first month of hospitalization and then return to the community; restart the second month of hospitalization after a while and then return to the community. The state-transition sequence is (m_1, c_1, m_2, c_2, E).

Case 3: Receive the first month of hospitalization and then return to the community; restart the second month of hospitalization after a while and then return to the community; restart the third month of hospitalization after a while and then return to the community. The state-transition sequence is $(m_1, c_1, m_2, c_2, m_3, c_3, E)$.

⋮

Case *F*: Receive hospitalization for *F* rounds. Since *F* is the final round of hospitalization, the state transition sequence is $(m_1, c_1, m_2, c_2, m_3, c_3, \ldots, E)$.

Let C_k^{npac} be the treatment cost of a non-PAC patient receiving *k* months of hospitalization, where $1 \leq k \leq F$. The average treatment cost of a non-PAC patient can be expressed by following equation:

$$C_k^{npac} = C_1^{npac} + P_{c_1,2}^{npac} \times C_2^{npac} + P_{c_1,2}^{npac} \times P_{c_2,3}^{npac} \times C_3^{npac} + \cdots$$
$$= C_1^{npac} + \sum_{m=1}^{F-1}((\prod_{k=1}^{m} P_{C_k,k+1}^{npac}) \times C_{k+1}^{npac}) \quad (2)$$

The average treatment cost of a non-PAC patient can be calculated from Equation (2) if the probability of each transition and the treatment cost in each stage of hospitalization are known.

2.2 Computational Model

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To empirically evaluate the financial effectiveness of the PAC plan, data on 350 stroke patients were collected from a regional hospital in Taiwan over the period of 2016/01 to 2017/09. Among the sample patients, 103 of them joined the PAC plan and the rest did not join. Among the 247 non-PAC patients, 195 of them were qualified to join the plan, while the remaining 52 were not qualified because their health status was considered to be too critical. Table 1 reports the average weekly NHI payment received by a PAC patient from week 1 to week 12, along with the probability of a PAC patient continuously receiving rehabilitative treatment in the subsequent week. The weekly NHI payment, which covers bed charges and nursing fees, is on average NT$ 8,365 = 7 × (532 + 663) (approximately USD 40/week).

Table 1. Weekly NHI payment and transition probability of a PAC patient continuously receiving treatment in the subsequent week

	Week 1	**Week 2**	**Week 3**	**Week 4**
Payment(NT$)/prob.	27,376/96%	27,171/100%	27,277/98%	25,934/96%
	Week 5	**Week 6**	**Week 7**	**Week 8**
Payment(NT$)/prob.	25,330/100%	25,710/96%	23,766/72%	24,613/60%
	Week 9	**Week 10**	**Week 11**	**Week 12**
Payment(NT$)/prob.	24,958/70%	24,593/92%	21,203/63%	21,185/ -

Table 1 suggests that the minimum average payment is NT$ 27,376 (approximately USD 912) if the patient completes only the first week of treatment and quits the plan thereafter. The probability for such a scenario to occur is 4% (= 100% – 96%) as shown in the table. The maximum average payment is NT$ 299,116 (= 27,376 + 27,171 + 27,277 +…. + 21,185, approximately USD 9,970) if the PAC patient completes 12 weeks of treatment with a probability of 15.2% (= 96% × 100% × 98% × 96% ×⋯ × 63%). Table 1 and Equation (1) indicate that the average treatment cost of a PAC patient is NT$ 141,744 (USD 4,724), which is calculated as follows:

$$27376 + 96\% \times 27171 + 96\% \times 100\% \times 27277 + 96\% \times 100\% \times 98\% \times 25934 + \ldots = 213{,}713$$

Table 2. Transition probability of a non-PAC patient continuously receiving hospitalization

	Month 1	**Month 2**	**Month 3**	**Month 4**
probability	83%	72%	62%	46%
	Month 5	**Month 6**	**Month 7**	**Month 8**
probability	32%	12%	2%	0%

Unlike a PAC patient, a non-PAC patient rarely remains at the same hospital for more than one month. The hospitalization data on non-PAC patients were obtained through a survey questionnaire because the NHI data on these patients are confidential. A total of 53 valid questionnaires were returned. The probability of a non-PAC patient continuously receiving hospitalization is reported in Table 2.

Since the health status of non-PAC patients is on average worse than that of PAC patients, the former can be provided with less intensive rehabilitative treatment. Table 2 shows that the re-admission rate decreases to zero after the eighth month of hospitalization. According to past experience, the NHI payment for a non-PAC patient mainly covers bed charges and nursing fees multiplied by 30 with a surcharge of 10% (for medicines and other expenses). As such, the minimum the average payment is NT$

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39,435 (= 1195 × 1.1 × 30; approximately USD 1,314) if the non-PAC patient receives hospitalization only for the first month, which has a probability of 17% (= 100% – 83%) to occur. The maximum average payment is NT$ 315,480 (approximately USD 10,516) if the non-PAC patient receives hospitalization for 8 months with a probability of 0.13% (= 83% × 72% × 62% × 46% ×2%). According to Table 2 and Equation (2), the average payment for a non-PAC patient is NT$ 119,484 (or USD 3,982), which can be calculated as follows:

39435 + 83%×39435 + 72%×83%×39435 + 62%×72%×83%×39435 + …
= 119,484

The average payment for a PAC patient (NT$ 213,713) and that for a non-PAC patient (NT$ 119,484) indicate that the former is paid more than the latter. However, the precision of such a difference cannot be absolutely ascertained because the data on the non-PAC patients were collected from a survey questionnaire. To a certain extent, the findings illustrate how NHI can reduce treatment costs by not re-admitting non-PAC patients into hospitals.

3. CONCLUSION AND LIMITATIONS

The management of rehabilitative treatment after the acute treatment of stroke patients has been well documented in the literature. National insurance providers all over the world have developed appropriate protocols, e.g., Taiwan's post-acute care (PAC) plan, governing the provision of rehabilitative treatment for stroke patients. This study proposes a Markov chain model to illustrate the distinct treatment pathways of PAC and non-PAC patients. This model works in a similar way to a time-series analysis of the treatment costs and transition probabilities for describing the problems faced by stroke patients in different treatment states. The average treatment cost can be calculated if the treatment costs and transition probabilities in each treatment state are known. This study collected data from a regional hospital in Taiwan for evaluating and comparing the National Healthcare Insurance (NHI) payments for PAC and non-PAC patients. The results show that the NHI payment for a PAC patient is on average smaller than that for a non-PAC patient. This study is the first in the literature to quantitatively measure NHI payments using a Markov chain model. However, this study's findings are based on data collected from a regional hospital in Taiwan and thus cannot be directly applied to other hospitals unless detailed treatment costs and transition probabilities are known.

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